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*ASTIGMATISM AS A FACTOR IN THE CAUSATION
OF MYOPIA.**

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The proposition to which attention is directed may be stated thus: "Myopia is commonly a disease which may be prevented by the early correction of astigmatism, conjoined with such other factors as are known to prevent eye-strain."

By myopia is meant a disability of the eye in which rays of light from an infinite distance come to a focus before they reach the retina. In this discussion, etiology is confined to the causes which produce actual elongation of the eyeball in its antero-posterior diameter by the yielding of its posterior walls. Scarpa first noticed this elongation in 1801, but it remained for Arlt, in 1856, by dissections to connect it with the myopic eye. Later von Graeffe and others showed the relation of this elongation to the posterior staphyloma, observed with the ophthalmoscope. Studies of millions of eyes, by thousands of observers, have given us data for a comprehensive knowledge of the gradual changes observable by the ophthalmoscope during the several steps from the beginning of myopia to its last stage of total blindness.

These data show "that there is at birth a predisposition to myopia, though but few cases of actual congen-

* Read before the Detroit Academy of Medicine.

ital myopia have been observed; that it is developed with symptoms of irritation in moderate degrees of staphyloma; that in the higher degrees an inflammatory state almost always occurs as a result, and as a coöperative cause of the further development of the distention and of the atrophy."—(Donders.)

The first indication of the disease to be seen with the ophthalmoscope is a light crescent at the border of the optic disc. This, little at first, broadens in all directions until it may occupy a very considerable section of the posterior portion of the eyeball. With this occurs a change in the shape of the optic disc by which its greatest diameter is seen in a direction at right-angles to the axis of the atrophy of the choroid. The retinal vessels are straightened. There is incomplete diffuse atrophy of the choroid in other places. There are circumscribed changes in the yellow spot and the *fovea centralis*. Occasionally there is a disseminated choroiditis; spots of extravasated blood in the retina; detachment of the retina by blood or serum; glaucoma; movable flakes in the fluid vitreous; and obscuration of the lens. It is not claimed that all or even the majority of cases of myopia will present these several stages of ophthalmoscopic appearance or anatomical change; but some of them do, and it is impossible to say at the beginning which one may take on this malignant form.

The causation of myopia has received the attention of the ablest of physicians and scientific students. Some

things are generally accepted respecting the conditions under which myopia prevails:

1. We know that it is more frequent in some countries than others. Thus among civilized peoples it is most prevalent in Germany.

2. It is more prevalent in cities and towns than in the country.

3. It is more prevalent among those classes who most constantly occupy constrained positions of the head or neck and fix both eyes upon fine work or minute objects of any kind.

4. All agree that it is least frequent among children before their entering school; that the number of cases of myopia, and the degree of each, increase with each succeeding school year until the completion of the university career.

5. No one doubts that an enfeebled constitution, from any cause, is a condition favorable to the production of myopia—especially in childhood and adolescence.

6. Nor is it disputed that those factors of school life which compel unnatural concentration of the eyes upon very close objects; that by faulty positions of the head and neck derange the blood supply of the eyes; that demand undue effort, to see poor print, or very fine print, to avoid glare of light, to maintain an erect position; that tax the eyes for such a period as to cause exhaustion, etc.; or that in any way place the eye at a disadvantage in its endeavor to adjust itself to its environment—all these combine to render the occurrence of myopia more

likely. But when we have removed all these conditions, we find that cases of myopia still occur with a surprising degree of uniformity, and pass through their several stages with more or less rapidity, showing that the school-house, however perfect, permits the development of myopia. Hence, with our present knowledge, there is no reason to believe that myopia can be prevented by the erection and maintenance of perfect school-houses. The most that can be affirmed is that such school-houses favorably modify the operation of other factors. In other words, bad construction and faulty maintenance of school-houses are simply accessory agents in the production of myopia, rather than the principal ones.

A convenient grouping of the causes of myopia is as follows:

1. General constitutional conditions—as low fevers, *la grippe*, etc.
2. Conditions under which the eye is used being conducive to overstrain—as bad light, bad air, undue confinement, bad postures, etc.
3. Functional activities of the eye—as accommodation, convergence, muscular pressure, etc.
4. Structure of the eyeball—hypermetropic, myopic, astigmatic.

Of the first we need not speak other than to remark that the use of the eyes by a person suffering from or convalescing from any severe illness, should only be permitted with great caution.

Of the second group of causes of myopia, viz., the

conditions unfavorable to the best use of the eye, I have to remark that in spite of the most favorable conditions experience shows that the myopia still keeps on increasing. Thus Dr. Derby, of Boston, made a special study of the eyes of the students at Amherst College, Massachusetts, for several years. At this college physical culture and perfect hygienic surroundings have been a "fad," so that the students get the best of conditions possible to secure. Yet even here, Dr. Derby tells us, there was an increase of over 10 per cent. during the four years of the college course. The same lesson has been learned from studies of numerous other schools lower and higher—all observers uniting in the verdict that the most perfect hygiene possible in the school will not check the progress of myopia.

Of the third group, much stress has been laid upon the pressure of the muscles, recti and oblique. That in convergence these do press hardly upon the eye, a superficial observation renders apparent. That in some cases an abnormal attachment of the superior oblique may so press upon the eyeball as to interfere with the venous circulation, is granted. It is also granted that some eyes may have such delicate sclerotic coats, particularly in their posterior portions, as to permit the normal muscular pressure to cause a bulging of the posterior portion of the eye, and to such an extent as to form a posterior staphyloma. There is still room for additional observations in this direction before we can say that muscular pressure in an eye having a normal structure can induce

myopia. Bearing upon this, is the record of an era during which muscular pressure was believed to induce myopia. Tendons of eye muscles were divided with great freedom and frequency; but such surgery in no degree abated the prevalence of myopia or checked its progress. Nor is there any evidence that the present epidemic of graduated tenotomy has checked the course of a single case of myopia, much less prevented the development of fresh cases. Nor have we any evidence that the act of accommodation or of convergence in an eye of normal structure is able of itself to cause myopia. These functions of the eye only become vicious in their results when they are associated with astigmatism. Incidentally it may be noted that watchmakers are not subject to myopia, though with their strong single glass they look long and intently at small objects. Nor have I known of a one-eyed person becoming myopic. Possibly the saving factor in these cases is the elimination of convergence from the act of seeing.

This brings us to the last group of causes of myopia, viz.: those relating to the structure of the eyeball. That the myopic eye tends to increase the degree of its myopia is universally acknowledged. It is also admitted that an emmetropic or hyperopic eye rarely, if ever, becomes myopic—they usually to the end of life remain as they began it. But the astigmatic eye often does change to a myopic eye, and the myopic eye to a myopic astigmatic eye. So frequent is this degenerative change that astigmatism is termed the “turnstile,” over which a sound eye

is turned into a diseased one. The following abstract of some recent studies on this point is of far-reaching value.

Some fifteen years ago Dr. S. D. Risley, of Philadelphia, became impressed with the idea that some peculiarity in the structure of the eyeball was the cause of the development of myopia. In the study of this idea he made an extensive examination of the children in the Philadelphia public schools. Using the ophthalmoscope, he ascertained the gross lesions of the eyes as well as their functional disabilities. His results were published in the Transactions of the Pennsylvania State Medical Society for 1881. He found that emmetropic eyes had the highest acuity of vision and were comparatively free from pain or disability of any sort. Through each succeeding class these eyes maintained nearly a uniform percentage. On the other hand, he found that those who entered school with anomalies of refraction were found to suffer from asthenopia and presented those intra-ocular changes which unquestionably related them to the myopic eye.—Later he undertook another investigation to prove the same proposition from the opposite standpoint. Thus, if these congenital anomalies of the eyeball caused myopia, then their early correction would arrest the development of myopia. The results of this study he gives in the *Archives of Ophthalmology*, July, 1894. If his view is sound, and it were possible to correct the anomalies of refraction of every child before it learned to read, and to maintain the correction during the period of growth by treatment at suitable intervals, then myopia

should disappear, aside from the few congenital cases. Of course Dr. Risley could not do this, but he approximated it so far as possible. It is well known that during the past twenty years or more it has been the custom in Philadelphia to correct all errors of refraction, and generally under atropine, thus ensuring the most perfect detection and correction of the defects.—Dr. Risley collected from his own case-books during the twenty years under consideration the records of nearly nine thousand cases carefully studied under a mydriatic. To these records he added those of a large firm of opticians which it had accumulated during the same period; in round numbers these aggregated about one hundred and ninety thousand cases. Thus he has the records of about two hundred thousand refractive cases during the period from 1874 to 1894.

Table (S. D. Risley, Archives of Ophthalmology, July, 1894) showing by years the steady and rapid decline of the percentage and grade of myopia.

Years.	Myopic Eyes.	Simple Myopia.	Myopic Astigmatism.	M. 10 D. or Higher.	M. 7 D. to 10 D.	M. 3 D. to 7 D.	M. 1 D. to 3 D.	M. 1 D. or Less.
1874-80	28.43	15.5	85.5	2.58	2.36	11.77	9.5	2.3
1881-83	23.05	15.45	84.55	2.10	1.96	6.92	8.6	2.3
1884-86	22.07	5.75	94.25	1.67	2.90	8.43	7.8	1.9
1887-89	19.82	6.50	93.50	1.10	1.20	6.79	7.5	2.7
1890-93	16.78	5.66	94.34	1.37	1.47	5.27	5.5	3.1

We notice that in the period from 1874 to 1880 there were 28.43 per cent. of myopic eyes, while in the period from 1890 to 1893 there were but 16.78 per cent.—a diminution of about 12 per cent. in the myopic eyes.

During the same period, simple myopia had diminished about 10 per cent.; myopia of ten dioptrics or higher had diminished about 1 per cent.; myopia of seven dioptrics to ten had diminished 1 per cent.; myopia from three to seven dioptrics had diminished 6 per cent.; myopia from one to three dioptrics had diminished 4 per cent. Of myopic astigmatism there had been an increase of 4 per cent., and of myopia of 1 per cent. or less—an increase of one per cent. The original table gives the changes during each period of about four years, showing that the changes had been steadily going on during the entire time, of twenty years. The increase in the per cent. of cases of myopic astigmatism and the lowest grade of myopia, shows that the wearing of proper correcting glasses had prevented the change for the worse in many cases. However, the absolute number of these cases was less than at the beginning of the period.

In so far as they go, these studies prove that correction of astigmatism diminishes the number of myopes, and checks the progress of cases of myopia so that the worst damage to the eyeball in myopic eyes was not reached so frequently. In their individual work, ophthalmologists have long recognized the fact that full correction of astigmatism, constantly worn, does stop the progress of many cases of myopia, but the demonstration of

Dr. Risley with his two hundred thousand cases gives an augmented assurance of its correctness.

My personal records for the past twenty-three years contain many cases supporting these views, but lack of space forbids giving more than one :

J. H——, aged 12 years, was brought to me to be relieved of an obstinate blepharitis. Examination showed the existence of hyperopic astigmatism—right eye one-half a dioptric, left eye three fourths of a dioptric. In each case the axis of the cylinder was in accordance with the rule, viz., at 90 degrees. The relation of the astigmatism to the disease of the eyelids was pointed out to the parents, and the wearing of correcting cylinders urged. The advice was rejected, as the parents could not think of having their child “wear glasses.” Two years later the same child was brought back for relief from defective vision of his left eye. At the first examination, two years previous, the vision of each eye was perfectly normal, but at this latter visit that of the left eye had been reduced to $\frac{2}{10}$. Farther examination showed that the left eye had passed over to a myopic astigmatism of three-fourths of a dioptric, axis horizontal. The parents were now ready to accept advice, and cylinders were given the lad correcting his astigmatism. Since then the boy has grown to manhood without farther change in his eyeballs. Occasionally he reports to ascertain if any change in his glasses is called for.

I have found it the rule in this class of cases to see

similar results. The eye unaffected by myopia retains its integrity, and the myopic astigmatism remains stationary or nearly so. My own observation, covering about seven thousand cases, fully supports Dr. Risley's contention. If this be admitted, it is quite possible by correcting every case of astigmatism to prevent the damage to eyeballs wrought by myopia.

The early and continuous correction of astigmatism would be followed by a constantly diminishing proportion of myopic people, until at last we should practically abolish myopia from the earth. The increased attention given in all large towns to the correction of refractive defects makes it certain that even under present conditions the number of myopes is greatly held in check. If further observations shall confirm those presented, the prevention of myopia and its attendant disabilities is a very simple problem. Correct the astigmatism, correct it completely, and keep it corrected during the period of growth, and myopia is to a large degree prevented.

I venture to add that not only will the correction of astigmatism prevent the development of myopia, but it prevents many other disabilities. In this list are headaches and allied functional disorders of the nervous system; several forms of blepharitis; several forms of conjunctivitis; lack of equilibrium of the ocular muscles; certain forms of neurasthenia, etc., etc. The story of the discomfort, the disability, the misery and absolute loss in countless directions, induced in individual cases

by uncorrected astigmatism, can never be fully told, as only those who have been its victims can understand it.

To discuss the ways by which astigmatism induces myopia is impracticable now—interesting as such discussion would be. All grant that astigmatism greatly increases the labor of the eye in each act of vision. Only through a perfectly circular cornea can the rays of light form a focus at a single point on the retina. In astigmatism the cornea is flattened laterally, so that several acts of accommodation are needful in order that one act of vision shall be completed. All are familiar with the fact that a car-wheel deviating never so slightly from the perfect circle, by each revolution which it makes, suffers damage itself, and damages the track over which it runs and the car which it supports. In like manner the eye with a cornea deviating from a perfect sphere, by its every activity damages itself, the brain with which it is intimately associated, and indirectly any or every apparatus in the entire body. On the face of astigmatics are constantly hung out signals of distress, such as the corrugated forehead, the blinking eyelids, the partially closed lids, etc. Strange to say, these signals of distress are usually unrecognized, and the distorted expression ascribed to individual cussedness. Yet these signals are the results of nature's efforts to overcome the distortion of vision induced by an astigmatic eye. They point to a varying pressure upon the eye in different directions, but which always finds its greatest resultant on the posterior portion of the eyeball adjacent to the optic nerve.

To one who thoughtfully studies these efforts during each act of vision, the wonder is not that myopia or bulging of the posterior portion of the eyeball occurs in so many cases, but that any case escapes.

Finally, to make available for the public our present knowledge, it is suggested that each school board require of every scholar a competent physician's certificate that he or she is sufficiently sound in body and eye and ear to safely engage in the labors of the grade about to be entered. If astigmatism exist, require that it be corrected ere the child can be admitted to the school. Similar certificates should be required of each teacher. The systematic attention to sound bodies and sound eyes and ears would exert a most wholesome effect upon the entire community. It would not be long ere the people would make the school-houses, school-books, methods of study, hours of study, and all that pertains to the school life, such as to ensure a healthier, happier, stronger and better race of American citizens.

The practice would suggest to each man or woman, when entering upon any responsibility or labor, mental or physical, that he or she secure a clean bill of health ere making the final decision.

CONCLUSIONS.

1. In the majority of cases myopia is a disease of the eyeball of more or less gravity—a disease which not only diminishes sight, but tends to destroy it through organic changes in the sclerotic, choroid, vitreous, lens, etc.

2. Myopia cannot be cured—its treatment is limited to the restriction of its development, the curbing of its ravages, and the correction of its disabilities.

3. Myopia is induced, usually, by the efforts of the eye to perform its work when crippled by astigmatism. Accessory factors in the causation of myopia include all conditions which make it more difficult for the eye to see quickly and accurately, or which impair the nutritive supply.

4. Eyes normal in structure do not become myopic under the strain incident to life in the schools, or in business or professional pursuits; nor do they suffer from asthenopia, or interfere with the functions of the nervous system or any other apparatus in the body.

5. The prevention of myopia depends mainly upon the early correction of defects of structure, and the continuance of this correction, at least throughout the period of actual growth. To this it is wise to add such other conditions as will to the largest degree restrict eye-strain.

6. The most effective method of eliminating myopia from the race is the requirement of a physician's certificate of physical soundness from all who seek an entrance to the public schools, said certificate to include a correction of all astigmatic defects.

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